PAN-PACIFIC ENTOMOLOGIST
62(1), 1986, pp. 77–82

Morphological Malformations Among Scorpions of Puerto Rico and the Adjacent Islands

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Abstract.—Twenty-eight different malformations are detected and illustrated in scorpions of Puerto Rico and adjacent islands. Malformations are more common in buthids (17.5% of examined specimens) than in diplocentrids (4.7%). Pectinal malformations are the most common among buthids (9.2%) whereas the arisal of terminal leg spurs from tarsomere I instead of II is the most frequent among diplocentrids (1.6%).

The "normal pattern" is a construct made after noticing a phenomenon repeatedly in approximately the same way. Great deviations from the so-called "normal pattern" are called abnormalities or, for this paper, malformations. Malformations can be intuitively viewed as very extreme values or "outliers" in a frequency-class plot.

Malformations are one of the manifestations of biological phenomena, and, therefore, are of interest to biology. They might be related to environmental events such as radiation (Heatwole et al., 1970) or accidents, or to internal aspects of the organisms in question such as molting (Ćurčić et al., 1983) or teratologies (Holmberg et al., 1983; Walton et al., 1983).

When malformations affect structures of taxonomic importance problems might arise in deciding whether the structure represents a character of taxonomic value (Kaston, 1982; Lourenço, 1984; Mayr, 1968; Quintero, 1983; Tennenson and Gotlfried, 1983). Usually, a thorough inspection of additional characters of the specimen, especially if the malformation occurs in one member of paired structures, and a good acquaintance with the group under study is very useful for decision-making.

In scorpions striking malformations such as double tailed specimens have received much attention (Franganillo, 1937; Vachon, 1953). Less evident malformations are only occasionally reported (Armas, 1977a; Lourenço, 1984) and mostly in connection with taxonomic studies (Armas, 1976, 1977b; Francke, 1978). To my best knowledge, only two preliminary attempts to evaluate the relative occurrence of malformed structures in scorpions have been done and they show that leg and pectine malformations are the most common and those on the telson, pedipalps, and chelicera less frequent (Armas, 1977a; González, 1984). These data might be of importance in the evaluation of possible changes in the intensity of factors causing malformations and, perhaps, might open new research avenues to the understanding of their possible genetic basis (Ćurčić et al., 1983).

The purpose of this paper is to enumerate and illustrate most of the malfor-

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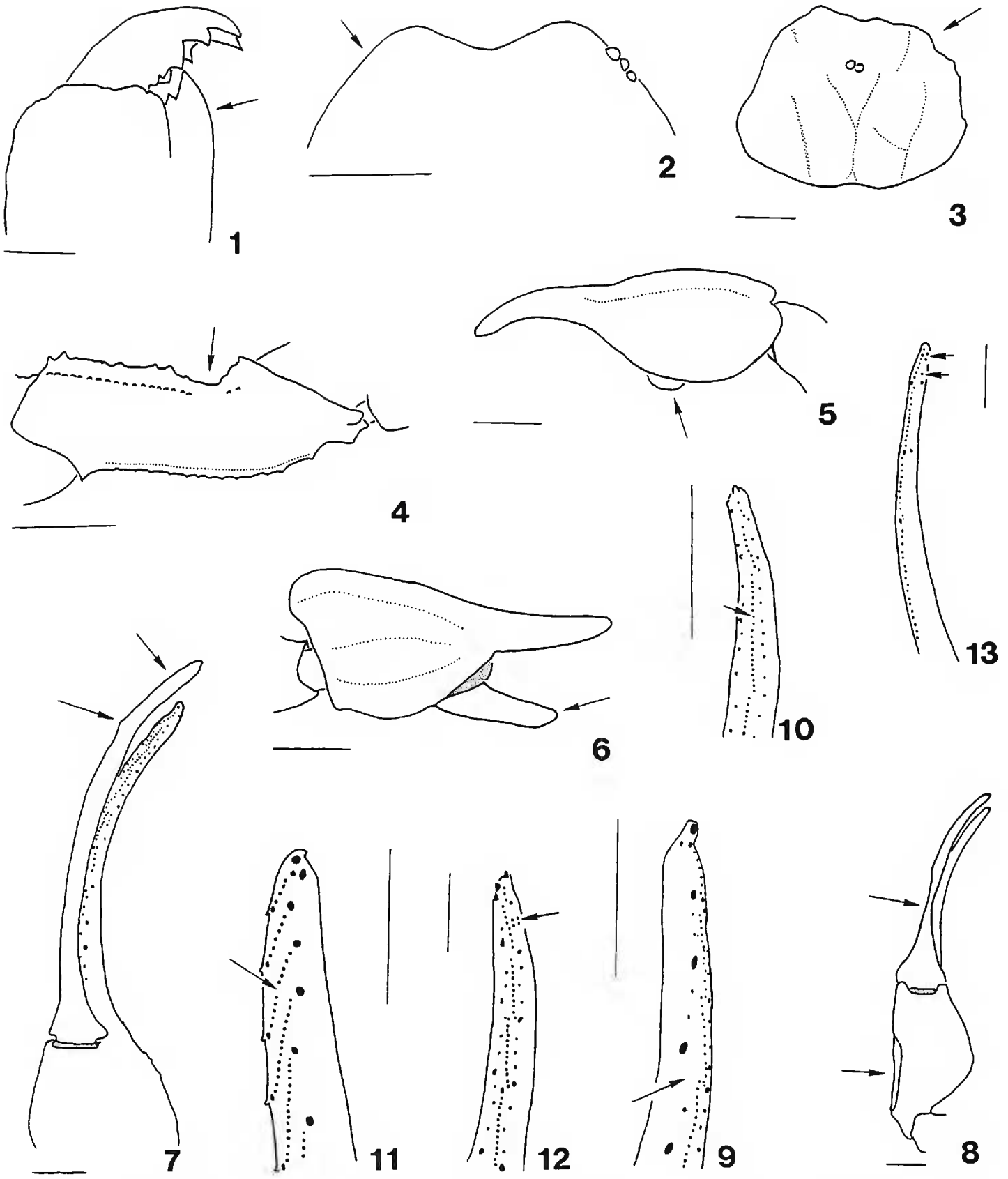

The acronyms herein used and their meanings are: AES (Agricultural Experiment Station, Entomology Museum, Río Piedras, PR), BM (Biology Museum, University of Puerto Rico), JASB (author's personal collection), MSC (miscellaneous scorpion collections of several individuals available through the author), UZM (Universitets Zoologisk Museum, Copenhagen, Denmark), WO (William Ortiz personal collection available through BM), and ZM (Zoologisches Museum an der Humbolt Universitat, Berlin). Field data for each illustrated case follows figure title and scale.

Figures 1–13. 1. Reduced chelicera fixed finger of *Centruroides* sp. Scale line = 0.5 mm. MONA IS: Trail from Sardinera to Capitán, 1979 (M. Alvarez and C. Aranda) (BM XVI-29). 2. Absence of a lateral eye group of *Heteronebo portoricensis* Francke, 1978. Scale line = 1 mm. GUAYACAN IS: 1 ♂, 22.IV.82, under rock (JASB) (JASB-196). 3. Asymmetrical carapace of *Cazierius* sp. Scale line = 1 mm. MONA IS: 1 ♂, Bajura de los Cerezos, 29.VIII.82 (C. Cianchini) (BM XVI-99). 4. Incomplete pedipalp femur keel of *Centruroides griseus*. Scale line = 1 mm. BRITISH VIRGIN ISLANDS: 1 ♀ (subadult), Little Tobago Island, 4.IV.66 (Island Project Staff) (BM XVI-150). 5. Extra protuberance on pedipalp chela of *H. portoricensis*. Scale line = 1 mm. PUERTO RICO: 1 ♀, Guánica, 12.III.72

mations found during the examination of 1245 specimens from Puerto Rico and the adjacent islands and to evaluate the relative frequency of the most common ones.

Results and Discussion

The following malformations were detected among the specimens studied: chelicera fixed finger not reaching the level of the movable finger apex (Fig. 1), absence of a lateral eye group (Fig. 2), carapace front margin deformed (Fig. 3), pedipalp femur keel incomplete (Fig. 4), protuberance on pedipalp manus (Fig. 5), pedipalp movable finger small (=not reaching the level of the fixed finger) (Fig. 6), pedipalp movable finger large (Fig. 7), pedipalp manus and finger scarps (Fig. 8), absence of supernumerary granules (Fig. 9), coalescence of non basal primary denticle rows (Fig. 10), absence of primary row denticles (Fig. 11), extra supernumerary granules (Figs. 12, 13), palp-fixed finger area incisioned (Fig. 14), terminal spurs of legs arising from femur (Fig. 15), spurs arising from tarsomere I (Fig. 16), tarsomeres I–II coalesced (Fig. 17), enlarged and bifid terminal spur (Fig. 18), enlarged terminal dorsal leg spine (Fig. 19), extra pectinal tooth very reduced (Fig. 20) or deformed pectinal teeth (Fig. 21), scars on mesosomal terga (Fig. 22), metasomal segment keels deformed (Fig. 23), incomplete (Fig. 24), or absent (Fig. 25), protuberance on metasomal keel (Fig. 26), aculeus and subaculear tubercle deformed (Fig. 27), and telson vesicle with a scar (Fig. 28).

Malformations were found in 17.5% of the buthid specimens examined. Reduced or deformed teeth in the pectines is the most common malformation (9.2%) among specimens of this family. For example, 7.1% of the *Centruroides griseus* (Koch, 1845) specimens and 3.9% of the *Tityus obtusus* (Karsch, 1879) examined bear this malformation. Other commonly found malformations are: deformed metasomal keels (3.7% of the *C. griseus,* 1.8% of the *T. obtusus*), joined primary denticle rows (1.7% of the *C. griseus,* 1.4% of the *T. obtusus*), and split primary denticle rows (due to the absence of one or more of the denticles) (1.1% of the *C. griseus,* 2.3% of the *T. obtusus*).

Among diplocentrid scorpions, malformations were found in 4.7% of the examined individuals the most common being the arisal of the terminal leg spurs from tarsomere I instead of II, which was detected in 1.6% of the diplocentrid studied.

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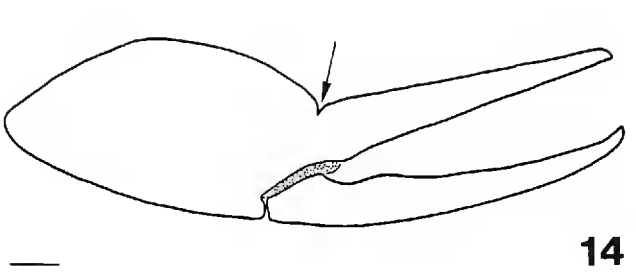
(unknown collector) (BM XVI-107). 6. Reduced movable finger of *Cazierius* sp. Scale line = 1 mm. MONA IS: 1 ♂ (subadult), 4.VII.67 (unknown collector) (BM XVI-94). 7. Enlarged movable finger of *Centruroides griseus.* Proximal arrow points possible origin of malformation. Scale line = 1 mm. PUERTO RICO: 1 ♀, Guánica State Forest, 3.IV.63 (F. Torres) (BM XVI-1). 8. Palm and movable finger scarps of *Tityus* sp. Scale line = 1 mm. PUERTO RICO: 1 ♀, Cayey, Guavate Forest, 3.III.77 (W. Ortiz) (WO-2). 9. Absence of a supernumerary granule of *Centruroides* sp. Scale line = 1 mm. MONA IS: trail from Sardinera to Capitán, 1979 (M. Alvarez and C. Aranda) (BM XVI-29). 10. Coalescence of non-basal primary denticle rows of *Centruroides griseus.* Scale line = 1 mm. PUERTO RICO: 1 ♂ [South West Puerto Rico], on a beach, 1.III.82 (R. Soto) (JASB-115). 11. Absence of a denticle on a primary row of *Tityus obtusus.* Scale line = 1 mm. PUERTO RICO: 1 ♀, Villalba, Toro Negro Forest, 20.VII.82, "dry pinus" (C. J. Cianchini) (BM XVI-112). 12. Extra supernumerary granules of *Centruroides* sp. Scale line = 1 mm. MONA IS: 1 ♀, no more data. 13. Extra supernumerary granules of *Isometrus maculatus* (DeGeer, 1778). Scale line = 1 mm. PUERTO RICO: 1 ♀, El Yunque, near La Mina, 1.X.63, loose bark (F. Torres) (BM XVI-42).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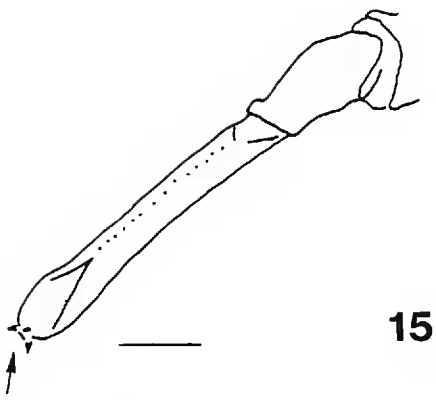
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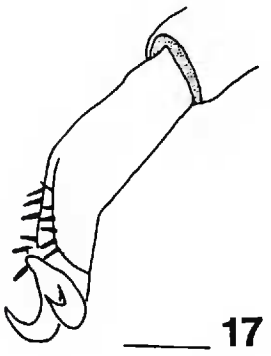
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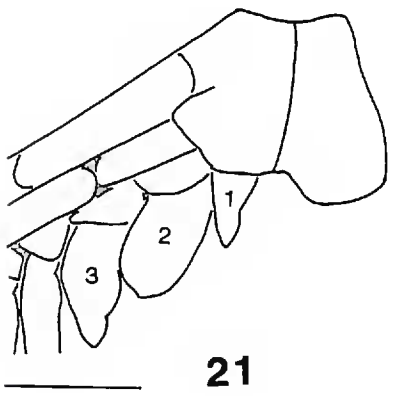

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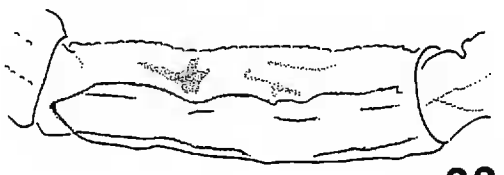
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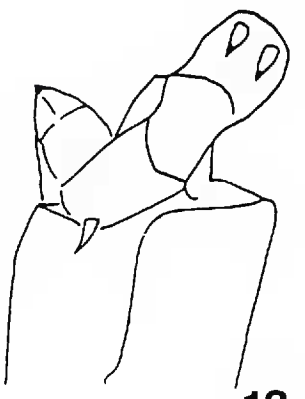
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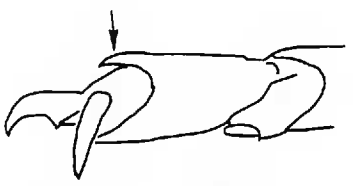
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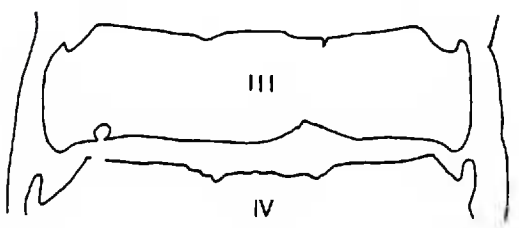

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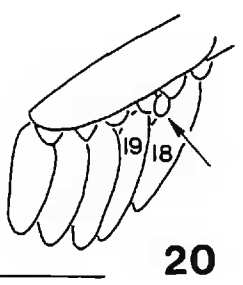

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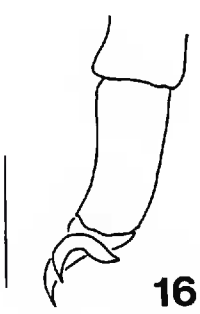
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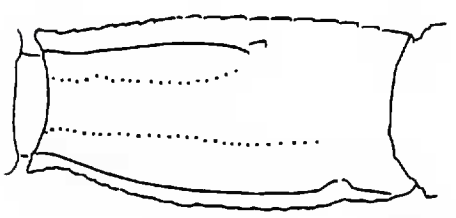
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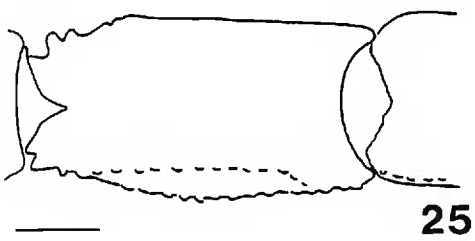
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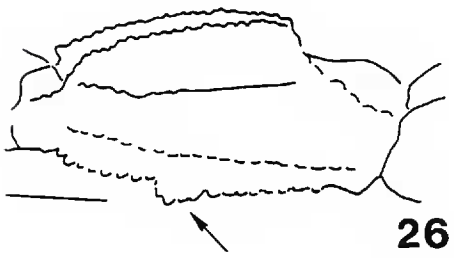
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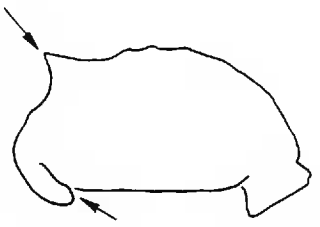
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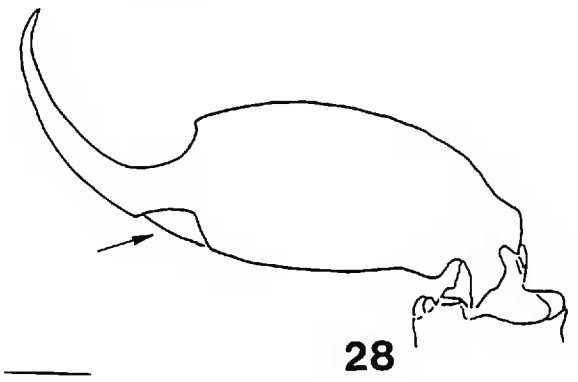
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Figures 14–28. 14. Palm-fixed finger junction area of *C. griseus* incisioned. Scale line = 1 mm. PUERTO RICO: 1 ♀ (juvenile), 18.XII.1888 (L. Krug) (ZM-7623). 15. Terminal leg spurs arising from femur of *C. griseus*. Scale line = 1 mm. PUERTO RICO: 1 ♂, Faro Beach, 4.III.82 (W. Irizarry) (JASB-145). 16. Terminal leg spurs arising from tarsomere I of *Cazierius* sp. Scale line = 0.5 mm. MONA IS: Bajura de los Cerezos, 25.XI.80, under rocks (M. Alvarez and V. Quevedo) (JASB-18). 17. Coalescence of tarsomeres I–II of *H. portoricensis*. Scale line = 1 mm. PUERTO RICO: 1 ♀, Ponce, behind Holiday Inn Hotel, 30.VIII.81, under rock (M. E. Arroyo and JASB) (JASB-85). 18. Enlarged and bifid terminal spur of *C. griseus*. Scale line = 0.25 mm. DESECHEO IS: 1 ♂, 6.VI.80, in a *Tillandsia* sp. (R. Thomas and JASB) (JASB-1). 19. Enlarged dorsal projection on tarsomere II of *Centruroides* sp. Scale line = 0.5 mm. MONA IS: Mujeres Beach, 21.I.82, dry rotten tree (JASB) (JASB-11). 20. Extra protuberance (fulcrum ?) between pectinal teeth of *Centruroides* sp. Scale line = 0.5 mm. MONA IS: Meseta, unknown date (R. Santo Domingo) (BM XVI-30). 21. Deformed pectinal teeth of *T.*

Most of the buthids inhabiting the Puerto Rico region have about three times more pectinal teeth than the diplocentrids, and therefore have a greater probability of having a malformation in the pectinal teeth (assuming all other possible factors equal). However, diplocentrids were found to have proportionately less frequency of pectinal abnormalities than expected. On the other hand, diplocentrids tend to be soil dwellers and are more likely than buthids to use the terminal segments of the legs for digging in the ground (thus breaking segments and producing spurs where they are usually not present).

Interestingly, malformations of the chelicera, chela manus or fingers, and telson, all of which might decrease prey capture efficiency, were found very few times (<1%), although other malformations on structures not so directly related to prey capture such as those on the pedipalp femur and tibia were also not frequent.

Acknowledgments

I wish to thank museum curators and workers whose help throughout the loan of specimens and exchange of communications contributed to the fulfillment of my M.S. thesis, a part of which this paper is: Mr. Luis F. de Armas (Colección Zoológica, Academia de Ciencias de Cuba), Dr. H. Enghoff (Zoologisk Museum, Copenhagen, Denmark), Dr. M. Moritz (Zoologishes Museum an der Humbolt Universitat, Berlin), Mr. P. Hillyard [British Museum (Natural History), London, Great Britain], Dr. J. E. Raastad (Zoologisk Museum, Universitet I Oslo), Dr. G. Anderson (Goteborgs Naturhistoriska Museum, Sweden), Dr. T. Kronestedt (Naturhistoriska Riksmuseet, Stockholm, Sweden), Dr. G. B. Edwards (Florida State Collection of Arthropoda, Gainesville), Dr. H. W. Levi (Museum of Comparative Zoology, Harvard University, Cambridge, MA), Dr. N. I. Platnick (American Museum of Natural History, New York, NY), and Dr. W. Pulawski (California Academy of Sciences, San Francisco, CA).

Dr. Stanley C. Williams (San Francisco State University, CA) read the manuscript and suggested changes.

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obtusus. Scale line = 0.5 mm. PUERTO RICO: 1 ♀, Orocovis, Sector Saltos Cabra, road 566, III.1983 (Saltos Cabra School Students) (JASB-497). 22. Scars on mesosomal terga margins of *T. obtusus*. Scale line = 1 mm. PUERTO RICO: 1 ♀, north side of Luquillo forest, 8.IV.61 (H. Heatwole) (BM XVI-276). 23. Completely deformed metasomal keels of *I. maculatus*. Scale line = 1 mm. "VESTINDIEN": 1 ♂, 12.VIII.1889 [M (=Meng)] (UZM). 24. Partially absent dorsal metasomal keel of *T. obtusus*. Scale line = 1 mm. PUERTO RICO: 1 ♀, north side of Luquillo forest, 8.IV.61 (H. Heatwole) (BM XVI-276). 25. Total absence of a dorsal metasomal keel of *T. michelii*. Scale line = 1 mm. PUERTO RICO: 1 ♀, 12.III.81 (A. Ramírez) (JASB-3). 26. Extra protuberance on a ventral metasomal keel of *Tityus* sp. Scale line = 1 mm. PUERTO RICO: 1 ♀, Toa Baja, road 2, km 21.3, pitfall trap, 28.V.82 (JASB) (JASB-35). 27. Partially deformed aculeus and subaculear tubercle of *C. griseus*. Scale line = 0.5 mm. UNITED STATES VIRGIN ISLANDS: 1 juvenile, St. John, Caneel Bay, 4.V.83 (W. I. Knausenberger) (MSC-2). 28. Vesicle scar of *C. griseus*. Scale line = 1 mm. PUERTO RICO: 1 ♂, Cabo Rojo, Boquerón, 12.II.82 (K. Rodríguez-Montalvo) (JASB-126).

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